HNF-41842-VA
Revision 0

Integration of System Components and Uncertainty Analysis: Hanford Examples

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

CH2MHILL
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Integration of System Components and Uncertainty Analysis: Hanford Examples

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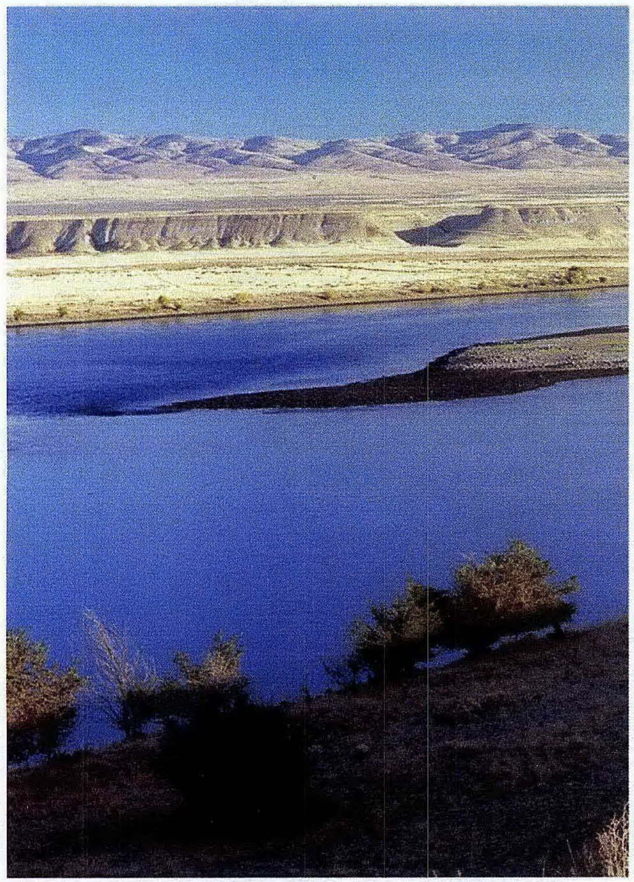

Integration of System Components and Uncertainty Analysis: Hanford Examples

Presented to: Performance Assessment Community of Practice Technical Exchange Meeting, July 13 – 14, 2009

Presented by:
Marc Wood, CH2M HILL Plateau Remediation Company

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Sensitivity/Uncertainty Analysis Description

- Deterministic "One Off" analyses as basis for evaluating sensitivity and uncertainty relative to reference case
- Spatial coverage identical to reference case
- Two types of analysis assumptions
  - Min/max parameter values around reference case conditions
  - "What If" cases that change reference case condition and associated parameter values
- No conclusions about likelihood of estimated result other than qualitative expectation that actual outcome should tend toward reference case estimate

Rationale

- **Deterministic "One Off" approach selected for several reasons**
  - Includes deterministic performance objectives
  - Generates basic "how the system works" understanding
  - Includes existing and in some cases extensive database enabling quantification of site-specific plausible value ranges for important parameters
  - Provides determination of performance adequacy generally obvious over range of future impacts estimated by sensitivity/uncertainty analysis
  - Identifies additional important data needs

Key Sensitivity and "What If" Analysis Parameters

- **Recharge history (surface barrier)**
  - Duration and rates for 3 phases: operational cover, surface barrier design life, surface barrier post design life
- **Source term characteristics (grouted tank structure)**
  - Inventory (10 times currently anticipated and possible retrieval leaks)
  - Release mechanism (diffusion and advection)
- **Hydrogeologic properties (subsurface zone)**
  - K_d
  - Vadose zone and aquifer hydraulic properties
  - Depth interval between waste and aquifer
  - Isotropic hydrologic properties

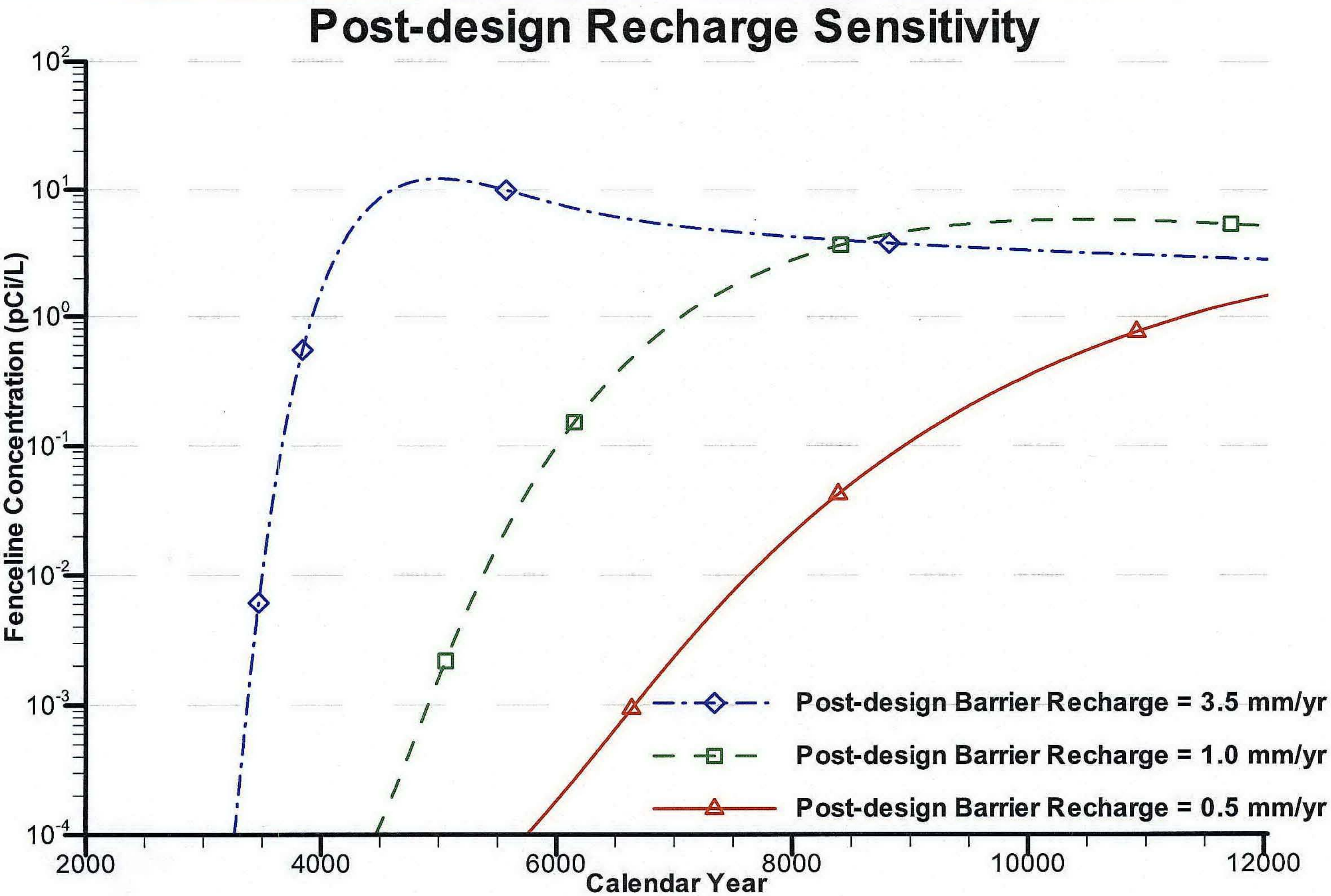
Parameter Variability

- Sensitivity parameter value ranges based on site-specific data and represent plausible real system variability (e.g., post-design life barrier recharge rates of 0.5 to 4 mm/yr)
- "What If" parameters differed in value and/or kind relative to sensitivity cases
  - Irrigated farming recharge rates (50 mm/yr in 2532)
  - Advective release from grouted tank structure
  - Isotropic media
  - Clastic dikes
- Strong emphasis placed on variations in recharge scenarios and associated recharge rates

Method Used to Compare Sensitivity Versus Reference Case Results

- Sensitivity (e.g., variability) expressed as ratio of peak or maximum value in sensitivity or "What If" case to corresponding reference case value
- Relative importance of parameters determined by comparison of ratios for each parameter
  - Ratios > or <1: Parameter influences contaminant migration and increases or decreases aquifer contamination depending on value relative to reference case assumption
  - Ratios ~1: Parameter has little or no influence on contaminant migration and aquifer contamination levels change little in response to parameter value change relative to reference case assumption

WMA C Tank Residual Contaminants, $K_d = 0$



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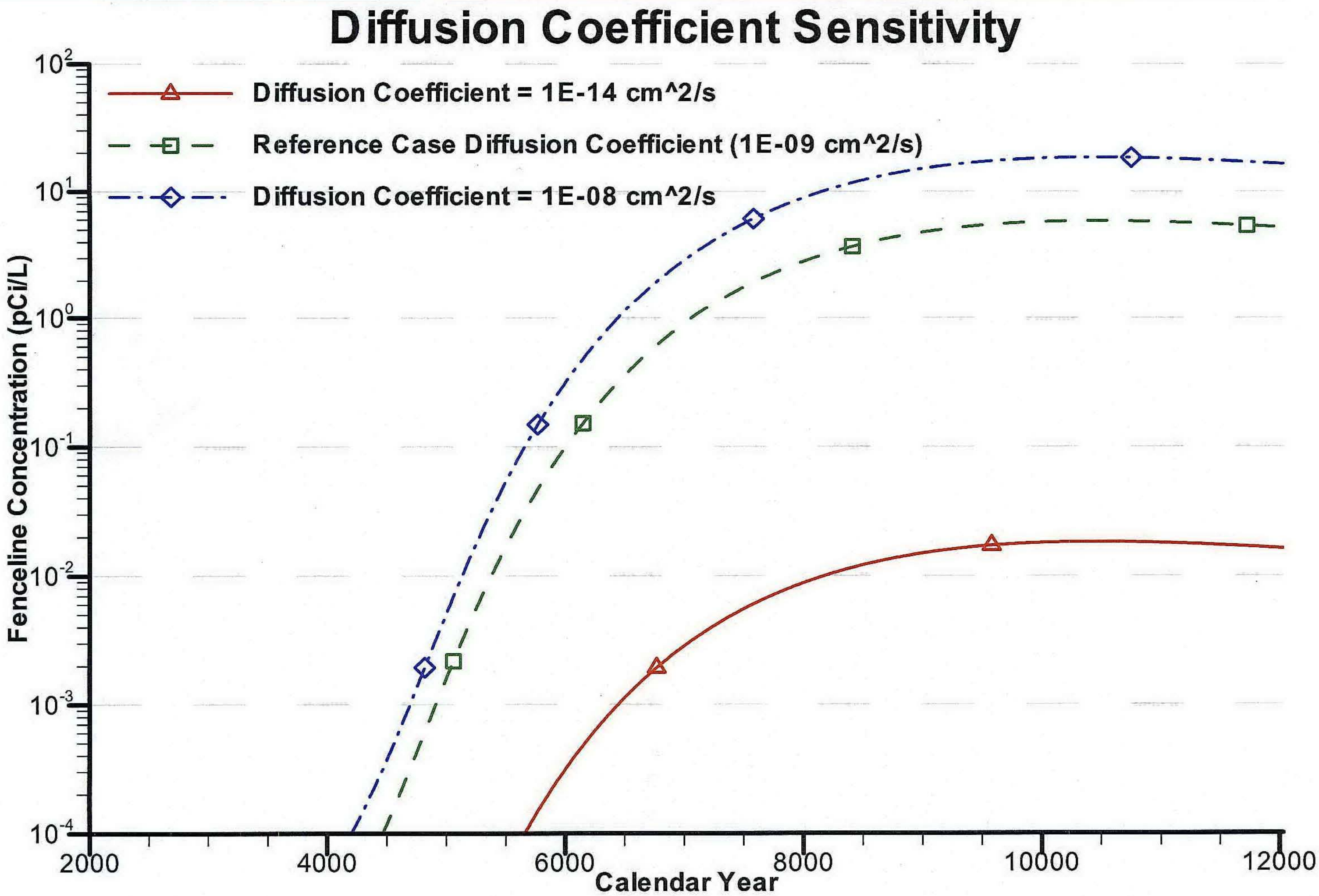

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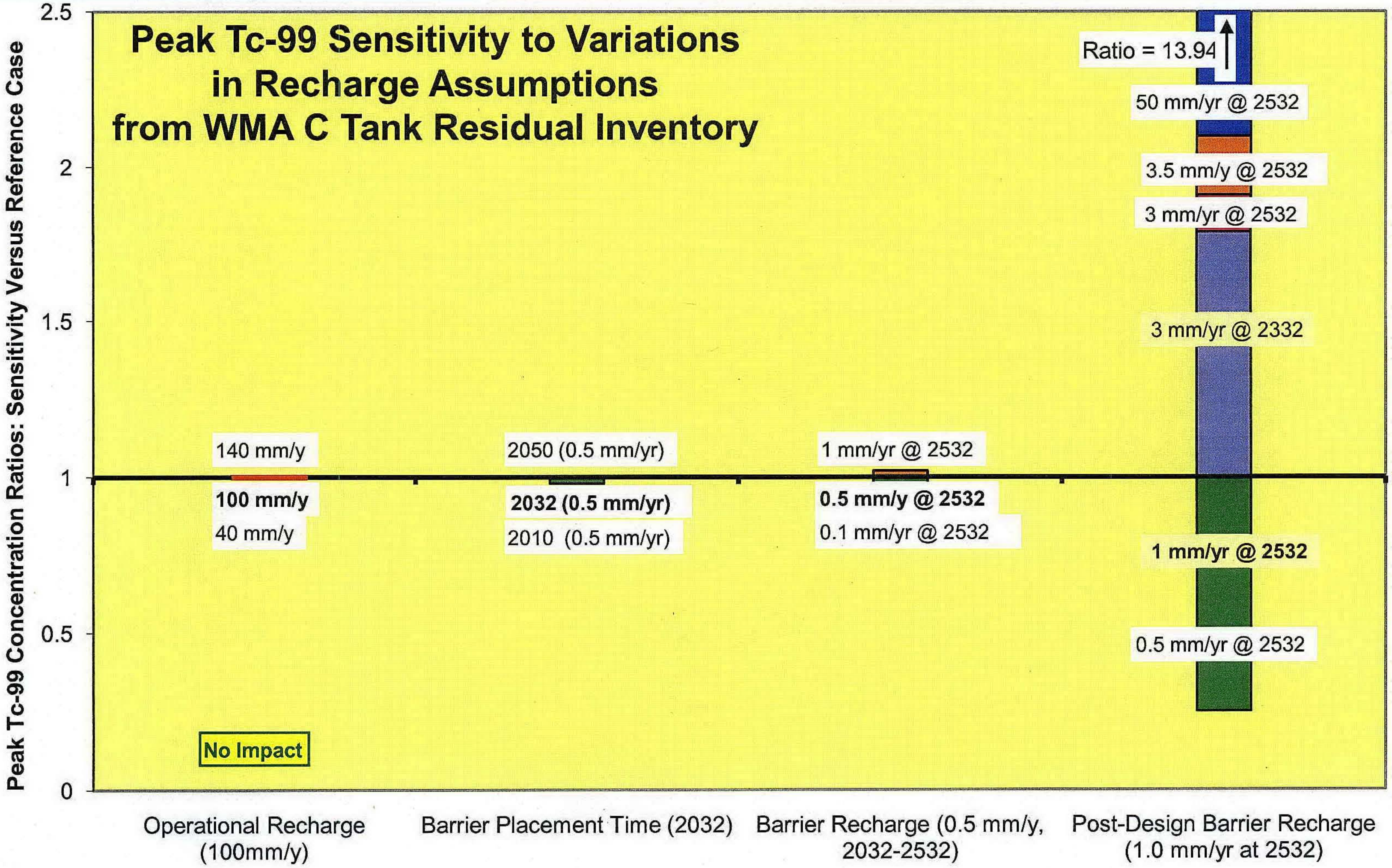
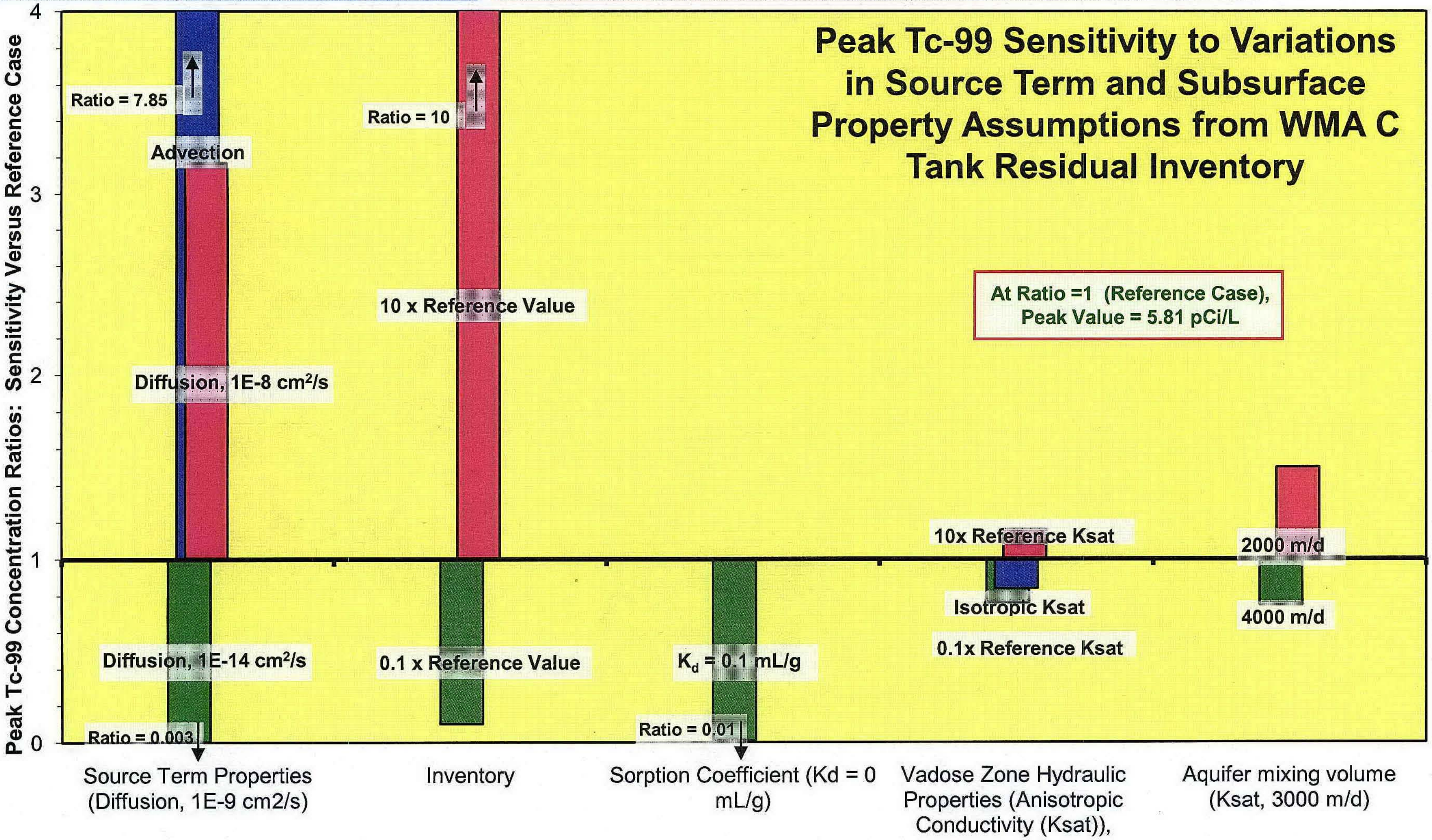
Peak Tc-99 Sensitivity to Variations in Recharge Assumptions



Peak Tc-99 Sensitivity to Variations in Source Term and Subsurface Property Assumptions



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Single Parameter Variability Effects for Residual Waste Contaminants with K_d = 0 mL/g

- Significant parameters
  - Inventory
  - Release mechanism
  - Post barrier design recharge rates
  - Aquifer mixing properties
- Inactive parameters
  - Operational recharge rates
  - Timing of barrier placement
- Peak value changes from expected parameter variability with respect to reference case values
  - Less than a factor of 10

Major Sensitivity/Uncertainty Results for Tank Residual Waste Releases

- Primary reference case conclusions were valid within plausible range of system variability
  - Only mobile or semi-mobile contaminants (e.g., K_d = 0 to <1 mL/g) estimated to reach aquifer within 10,000 year postclosure
  - Aquifer contamination from contaminants in tank residuals satisfies performance objectives
- Cumulative parameter variability effects could be generated from single parameter variability analyses
- Irreducible cumulative variability in groundwater contamination estimates varied by factor of ~10 for mobile constituents, the primary contributors to groundwater contamination

Future Sensitivity/Uncertainty Analyses

- **Options**
  - Explicit simulation of contaminant/water movement through engineered cover and/or tank structure acting as waste containment system
  - Evaluation of flow and transport through alternate physical system representations (e.g., addition of more clastic dikes, cracks through engineered barrier/tank farm structure, solubility controlled release)
  - Consideration of sensitivity analysis of additional system parameters
  - Probabilistic treatment of parameter variability to estimate sensitivity/ uncertainty of peak contamination level outcomes with respect to parameter and conceptual model variability

Future Sensitivity/Uncertainty Analyses

- **Decision Factors**
  - Added value of additional analysis complexity relative to system performance demands (e.g., how close are estimated environmental impacts to regulatory limits)
  - Completeness of existing flow and transport scenario evaluations (key processes, parameter variability and alternate conceptual models)
  - Capability to collect additional information needed to adequately describe more detailed process analyses and scope of probabilistic analyses